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A MANUAL OF MICROPHONE TECHNIQUES FOR ACHIEVING
BEST RESULTS IN TAPE RECORDING THE
HIGH SCHOOL BAND REHEARSAL

A Field Report
Presented to
The Graduate Division
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of the Requirements of the Degree
Master of Music Education

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by
Keith Allen Altemeier
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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background of the problem. The tape recorder has become a standard teaching aid in many schools with the development of high fidelity tape recording since World War II.[1] Because of its relative simplicity, ease of operation, and lower operational costs it has almost completely supplanted wire and disc recording. William Sur and Charles Schuller, in Music Education for Teen-agers have said, "The uses of the tape recorder in music are virtually without limits. It is at once a time saver, a convenience, and a powerful instructional tool."[2] Further, in The Band Directors Handbook it is stated, "The magnetic tape recorder is one of the band directors most valuable teaching tools."[3]

> Starting with the poorest home recording equipment and material, good educational recording has graduated to the best professional equipment, for only results of highest fidelity can satisfy the low-fatigue requirements of the school.[4]

Many schools have moderately good to excellent tape recording equipment, but through a lack of knowledge of the user they do not

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[1] John W. Molnar, "Teaching with the Tape Recorder," Music Journal, LXVI (May, 1961), 44.

[2] William R. Sur and Charles F. Schuller, Music Education for Teen-agers (New York: Harper and Brothers, 1958), p. 369.

[3] Clyde W. Duvall, The High School Band Directors Handbook (Englewood Cliffs, New Jersey: Prentice Hall, 1960), p. 175.

perform up to their capabilities. Mary and Robert Marshall have made the following statement:

> We have appraised recordings of school bands and orchestras -- not for artistic talent displayed, but to make suggestions about microphone placement and rearrangement of instruments before recording. Too often microphone placement has been determined by electrical outlet locations instead of by testing to find out where the best sound could be recorded.[1]

Sur and Schuller further asserted that music teachers should become skilled in the use of the tape recorder and the use of microphones to secure satisfactory recordings.[2]

The microphone is the weakest link in producing better recordings. "No recorder, no matter how good, will give maximum performance unless equipped with a good microphone."[3] The microphone is to the recorder what the mouthpiece is to the wind instrument. Marshall claimed that the greatest single limiting factor in most modertely priced tape recorders is the microphone that comes with them.[4] Regardless of how good a recorder may be, it can record only what it "hears." Thus, the microphone and the manner of its use are important considerations for the music teacher.[5]

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[1]Sur, op. cit., p. 358.

[2]David Hall, "Notes on Symphony Recording," Hi Fi Stereo Review, VI (April, 1961), 39.

[3]George Riley, "How to Choose the Proper Microphone," Electronics World, LXIV (September, 1960), 35.

[4]Marshall, op. cit., p. 132.

[5]Sur, op. cit., p. 358.

Microphone placement is a vital part of securing better recordings. David Hall, a professional recording director avowed, "Microphone placement is a very critical job -- one that, perhaps, influences the final result of the recording session more than any other."[1] George Riley has expressed, "Quite often, proper application of an inexpensive microphone will produce superior performance over a more expensive microphone, wrongly applied in the same application."[2]

Statement of the problem. The purpose of this study was to prepare a manual, for use by the school instrumental music director, of microphone techniques for achieving more satisfactory results in tape recording his school band. It is intended primarily as a guide to the director for recording under regular rehearsal conditions. It was not the primary purpose to set up guides for recording the band in concert or public appearance. Naturally most of the same materials will apply. It was the intention to develop guides to rehearsal recording with the available equipment, so that areas needing improvement can be cited in order to improve public performance.

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[1] David Hall, "Notes on Symphony Recording," Hi Fi Stereo Review, VI (April, 1961), 39.

[2] George Riley, "How to Choose the Proper Microphone," Electronics World, LXIV (September, 1960), 35.

Scope. It was the scope of this study to investigate the factors to be considered when purchasing a microphone to be used in recording the school band. The study includes a guide to determine the best microphone placement. This guide includes those types of microphones that are included with some tape recorders.

The writer has surveyed the following materials related to the subject. Included are: books on music education, acoustics, acoustical engineering, and radio engineering; periodicals in the high fidelity field; and pamphlets and catalogues from microphone manufacturing companies and tape recorder manufacturing companies. The writer has had a number of discussions with engineers in the field of recording to determine the importance of related topics and to guide him to materials.

Organization of remainder of the report. Chapter II has explained the terms and processes necessary to gain a thorough understanding of all the factors involved in the selection and use of the microphone. The final chapter relates these topics to the selection and the techniques of the microphone as they apply to the high school band director.

As an appendix, a tape was recorded to indicate how to achieve the best results in tape recording the school band and to substantiate those findings included in this manual.

CHAPTER II

EXPLANATION OF TERMS AND PROCESSES

An explanation of terms and processes related to tape recording is necessary to comprehend all factors involved in the selection and use of the microphone.

Sound. Sound may be defined as the sensation that affects the organs of the ear when certain vibrations are set up in the surrounding air. It may also be considered as the vibrations themselves or the energy that produces them. Sound waves in the air might be visualized as the waves that propagate from a pebble dropped in a pool. The difference is that sound waves are not limited to one horizontal plane.[1]

The sound wave in air consists of periodic changes in pressure in the direction in which the sound is traveling. The front of the wave may start as a compression of the air molecules at the point where the sound is produced. This compression causes a region of high pressure which pushes the adjacent air particles in an outward direction against the neighboring particles, thus causing the the compression to move away from the source. While this compression is moving away, the vibrating source is moving in the opposite direction, causing a lowering of the air pressure, called refraction, to follow the compression wave.[2] This process is continual as long as there is energy from the source of the sound.

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[1] Charles A. Culver, Musical Acoustics (New York: McGraw-Hill Book Company, Inc., 1956), pp. 18-19.

[2] Culver, op. cit., p. 19.

Sound has two important characteristics: (1) frequency, the number of vibrations per second which represents pitch; and (2) amplitude or intensity which determines the loudness.[1] Figure 1 is a graphic representation of a simple sound wave. Time is represented by the distance from left to right. A complete wave is the distance from one point on the wave line to a corresponding point on the next wave. The curve below the line represents the refraction of the sound wave. At the point of crossing the 0^{o} line there is neither compression or refraction.

Few sounds, indeed if any, are pure simple sound waves. Each sound is actually a composite or complex sound wave which includes the harmonics or overtones of a particular sound as well as its frequency and amplitude. Figure 2 shows the graphic wave form of G_3 and D_4 played on the B flat soprano clarinet.

As more instruments, such as in a band or orchestra, are included the sound wave becomes infinitely more complex. It is this complex wave that we are concerned with when recording the band. The ideal that is strived for is to have this sound wave be recorded exactly as it is and then be played back in exactly the same form as it was originally. As yet no completely perfect system has been developed, but with the improved

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[1] Robert and Mary Marshall, Your Tape Recorder (New York: Greenberg, 1955), pp. 13-14.

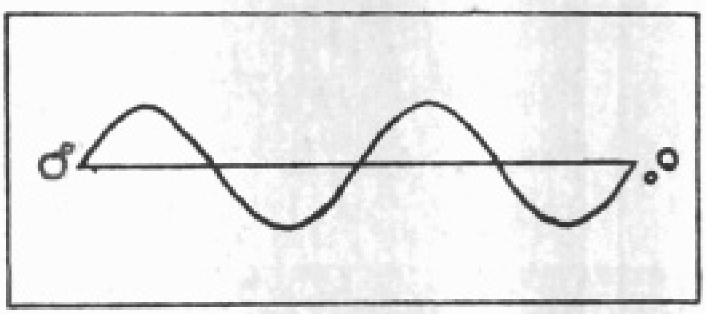

Figure 1. Graphic representation of a simple sound wave.
(From Culver, Musical Acoustics, 1956.)

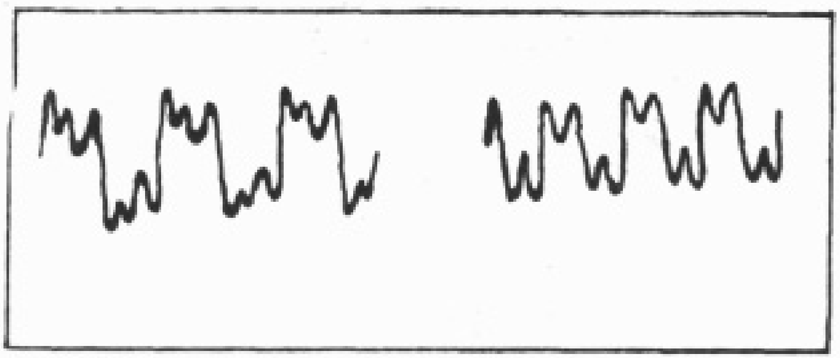

Figure 2. Graphic waveforms of clarinet tones: left, G3; right, D4. (From Culver, Musical Acoustics, 1956.)

sound systems developed in the past few years a reasonable approach to the ideal has been made.

The recording process. First, these sounds in the air must strike the microphone, the function of which is to transform these sound waves into corresponding electrical impulses. These impulses are of a varying intensity. They are extremely weak and must be amplified. These amplified signals are then fed to the recording head. The recording head is a very refined electro-magnet. As the recording tape, which has a fine magnetic material coating on one side, passes the recording head the electrical impulses affect this coating. As the tape passes on it retains these impulses that were applied by the recording head. Figure 3 shows the complete recording process in diagram form.[1]

The playback process. The playback process is nearly the reverse of the recording process with the microphone replaced by the speaker. The recorded tape is passed over the playback head, which in many cases is the same head as that used in recording. The playback head reproduces the impulses that correspond to those that originated in the recording process. These impulses are then amplified to sufficient power to operate the loudspeaker. Figure 4 is a diagram of the complete playback process.

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[1]Donald C. Hoefler, All About Hi Fi Tape Recording (Greenwich, Connecticut: Fawcett Publications, Inc., 1960), pp. 10-16.

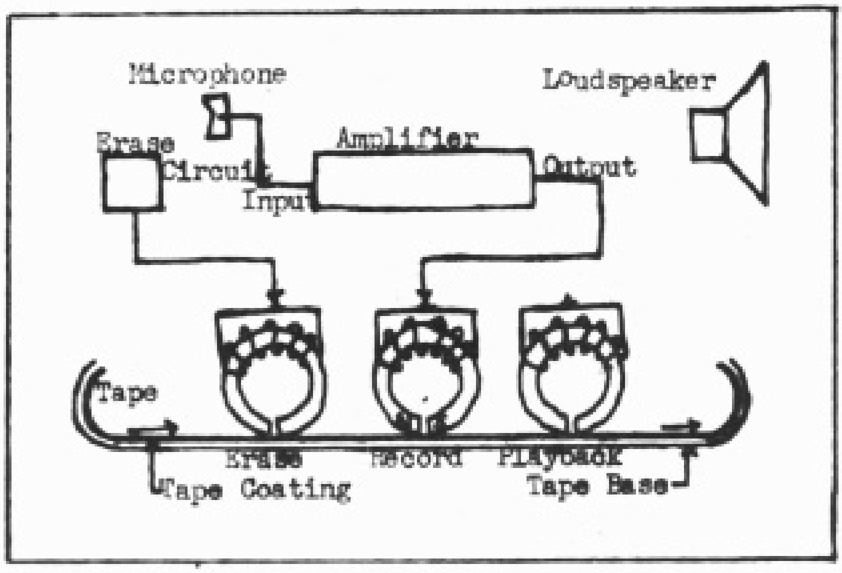

Figure 3. The recording process.

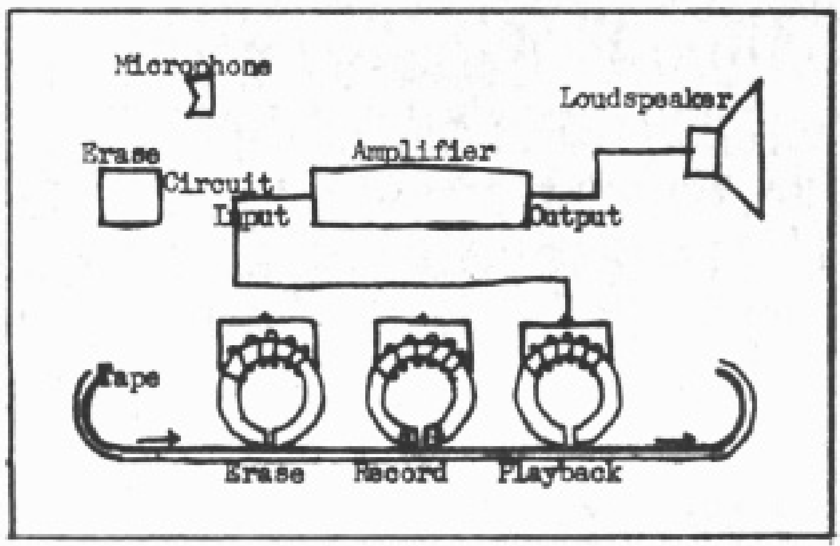

Figure 4. The playback process.

How accurately each of these components do their work is the determining factor in the fidelity of the resultant sound. As in the proverbial chain, the resultant sound is no better than that of the poorest of the components.[1]

Microphone. Sound waves must be converted into a usable form of energy before they can be recorded on tape. The microphone performs this function. It contains a diaphragm that is moved by the sound waves that strike it; the rate that it moves is dependent upon the frequency or pitch of the sound wave. This diaphragm is connected to a generator which translates that action into electrical impulses that can be amplified and used to record a magnetic field on a tape.

The compression and refraction of the sound wave causes the diaphragm to move to and fro, varying in speed as does the sound wave striking it. This variation then results in a like variation of the electrical voltage from the generator. How nearly the resultant pattern of electrical voltage matches the original sound is a measure of the quality of a microphone.

Microphones are classed as to type by the kind of generating element they contain. There are five basic types.

Carbon microphone. The earliest type, and probably the most common since it is the one that is found in the telephone hand set, is

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[1] Hoefler, op. cit., pp. 14-16.

the carbon microphone. It contains a diaphragm which exerts pressure upon a small container of carbon granules. An electrical current is passed through the carbon which varies in accordance with the changes in resistance of the carbon granules. The carbon microphone is rugged, but has a high internal noise level and a limited frequency response. It is not recommended for use in the recording of music.[1] Figure 5 is a pictoral diagram of a carbon microphone.

Crystal or ceramic microphone. Some crystalline materials have the property of generating an electrical voltage when a thin slab of it is bent or twisted. Rochelle salt and barium titanate are two of these materials commonly used in microphones. They are utilized in the crystal and ceramic types. The diaphragm is mechanically connected to a thin slab of crystal, or ceramic, which bends in sympathy with the diaphragm as it is moved by sound waves. This slab of crystal or ceramic is then connected to the amplifier. Figure 6 is a pictoral diagram of a crystal or ceramic microphone.

The crystal and ceramic microphones are low in cost and are light in weight. Most non-professional tape recorders come equipped with this type of microphone. However, they are affected by high temperatures and by high humidity. They are not recommended for good quality music recording.

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[1] Gordon J. Holt, "How to Choose a Microphone," Hi Fi Stereo Review, VIII (June, 1962), 39.

[2] Riley, op. cit., p. 36.

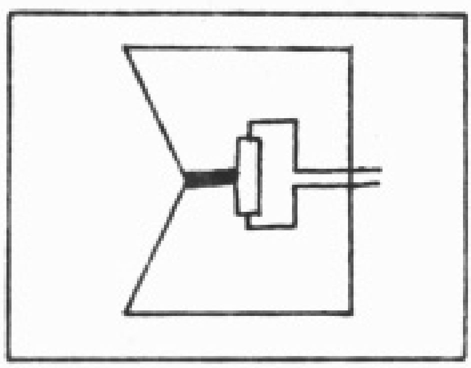

Figure 5. Carbon microphone.

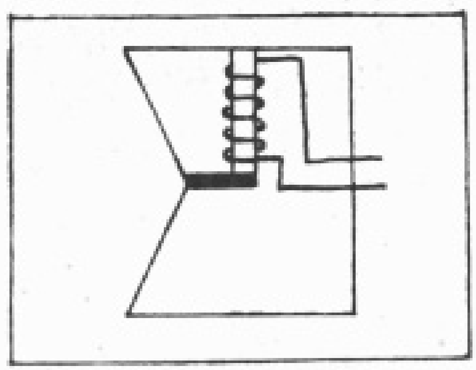

Figure 6. Crystal microphone.

Dynamic microphone. The dynamic microphone works much the same as a loudspeaker in reverse.[1] A voice coil is attached to the diaphragm which moves back and forth through a strong magnetic field. This generates a varying electronic signal which can then be carried to the tape recorder. Figure 7 is a pictoral diagram of a dynamic microphone.

The dynamic microphone can be built very compactly. Its cost is in the medium price range. It is very rugged and is not affected by moisture or temperature.

Ribbon or velocity microphone. The development of ribbon generating elements made possible the first high quality microphones in the early 1930's. They consist of a thin, compliant ribbon, usually aluminum, that is suspended between the poles of a strong magnet. A voltage is generated in the ribbon as it moves forwards and backwards through this magnetic field. This voltage is taken from the ends of the ribbon to be carried to the tape recorder. Figure 8 is a pictoral diagram of a ribbon microphone.

The ribbon microphone, sometimes called a velocity microphone, has a very wide frequency response but because of the high compliance of the ribbon, it is very fragile. It cannot be used outside as the ribbon responds even to the wind. Its cost is in the medium to higher price range.[2]

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[1]Holt, *op. cit.*, p. 40. [2]Holt, *op. cit.*, p. 42.

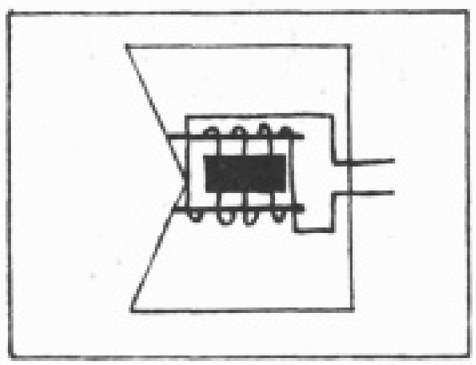

Figure 7. Dynamic microphone.

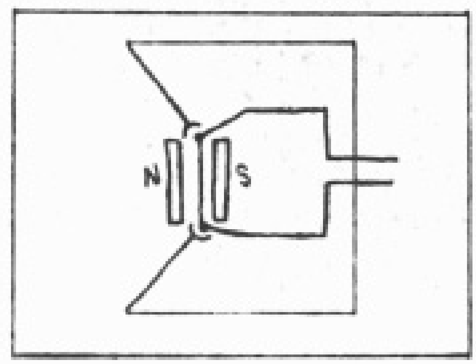

Figure 8. Ribbon microphone.

Condenser or capacitor microphone. The condenser or capacitor microphone is essentially formed by two plates separated by the air as a dielectric. One plate is fixed while the other serves as the diaphragm. The capacitance across the two terminals varies in accordance with the sound pattern. The output impedance of the condenser microphone is very high and requires a pre-amplifier, sometimes built into the microphone, which reduces the line impedance to a workable level. It also requires its own external power supply.[1] Figure 9 is a pictoral diagram of the condenser microphone.

The condenser microphone is used for laboratory tests and professional recording applications. It has a wide frequency response but its use is limited by its high cost.

Polar pattern. Irrespective of type, each microphone has its own pickup characteristics, or polar pattern. Appearance is not necessarily a true indication of a microphone's pickup pattern. As an example, a microphone that is completely closed on the sides and back does not necessarily respond to sounds that come only from its front. It may respond to sound waves from the back and sides just as strongly as those from the front.

The pickup patterns can be categorized into four general classes: omnidirectional, bidirectional, unidirectional, and cardiod. The omnidirectional microphone responds to sounds with nearly the same intensity

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[1] Holt, *op. cit.*, p. 43.

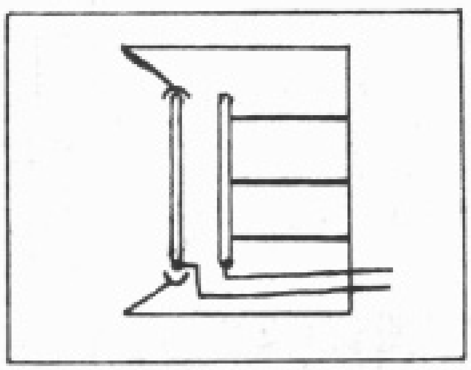

Figure 9. Condenser or capacitor microphone.

from all sides. This is true even though the microphone is facing in a horizontal plane. The bidirectional unit responds primarily to sounds emanating from the front and back. The unidirectional microphone accepts sounds from one direction only. The cardiod is in actuality a special kind of unidirectional microphone but is included here because it is used frequently in the recording of music. It accepts sounds that come from within a heartshaped area at its front. Pickup characteristics are diagrammed on a polar graph with the microphone understood to be in a horizontal plane at the mid-point and facing 0°. The four above named polar responses can be diagrammed as in Figure 10. The maximum response is indicated when the dark line falls on the outside circle. As the dark line falls toward the center the response from that angle becomes less. The line cannot be interpreted in any way as a measurement of distance. It indicates only the response with 0° being the maximum for the given microphone.[1]

Frequency response. Another important factor in the consideration of microphones is frequency response. The perfect microphone would respond with equal intensity at all frequencies. However, in actual practice this has not been achieved.

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[1] Harold Weiler, Tape Recorders and Tape Recordings (Mineola, New York: Radio Magazines, Inc., 1956), pp. 48-51.

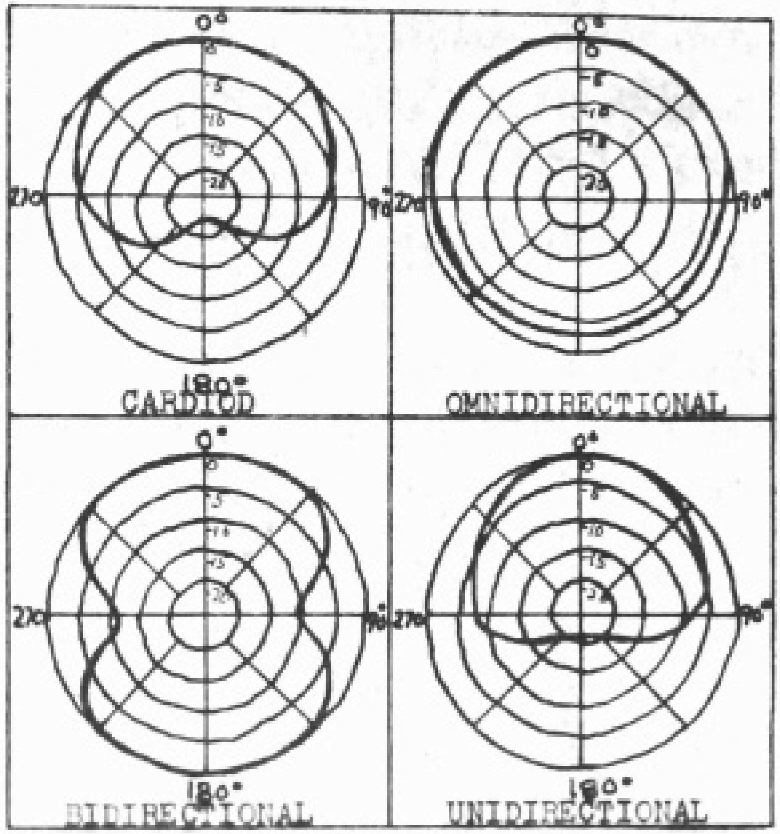

Figure 10. Microphone polar patterns. (From Weiler, Tape Recorders and Tape Recording, 1956.)

Frequency responses are usually expressed in terms of a range between whose limits the microphone will yield a usuable output, such as 70 to 12,000 cycles per second (abbreviated c/s in microphone specifications).[1] This means that the microphone will respond to frequencies from 70 to 12,000 c/s; but it does not give any indication of how accurately the microphone responds to all frequencies within this range.

A more accurate indication of a microphone's frequency response capabilities is a frequency response curve, showing the output as a continuing line from the lowest to the highest frequency that it responds to. In Figure 11, line A represents the microphone that would have the perfect frequency response. Line B represents a response curve for a typical inexpensive crystal microphone. Notice that the microphone represented by line B has a completely accurate response at only those points where it crosses the reference line. The conclusion then, is that the more linear, or flat, the response line is the more accurately the microphone responds to all frequencies.[2]

Frequency response necessary to record band instruments faithfully. Musical sounds are a complex sound wave made up of components called partials. The lowest partial is designated as the fundamental. This is the tone or pitch that is most often predominant. The partials have higher frequencies and are referred to as overtones. In many

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[1]Marshall, op. cit., pp. 13-14. [2]Marshall, op. cit., p.15

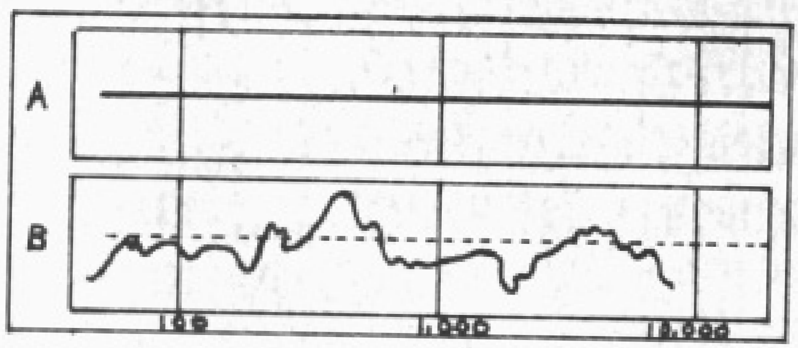

Figure 11. Line A represents a flat frequency response. Line B is a response curve for an inexpensive crystal microphone. (From Weiler, Tape Recorders and Tape Recording, 1956.)

instances these overtones are exact multiples of the fundamental. In such cases they are called harmonics.[1]

Culver, in Musical Acoustics, wrote that the quality or timbre of a musical sound is determined chiefly by the number, intensity and distribution of the partials entering into its composition.[2] Further, in the Practical Hi Fi Handbook it is maintained, "It is the presence of overtones or harmonics which is responsible for the difference in quality between the sounds produced by the orchestra."[3]

These harmonics are not present with the same intensities. Some partials may even be absent. Relative harmonic content is graphically shown by a sound spectrum chart. Figure 12 is sound spectra charts for two instruments of the band.

The length of the vertical line indicates the relative strength of the several partials present in the sound. These sound spectra will change for each instrument, and indeed for each pitch on the same instrument, although in the later case the change will be relatively small. The important consideration here is that if an exact semblance of the sound of wind instruments is going to be made not only the fundamentals but the harmonics also must be authentically recorded. The intensity as well as the pitch of each partial must be the same as they

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[1] Culver, op. cit., p. 103. [2] Culver, op. cit., p. 105.

[3] Gordon J. King, The Practical Hi Fi Handbook (London: Odhams Press Limited, 1960), p. 15.

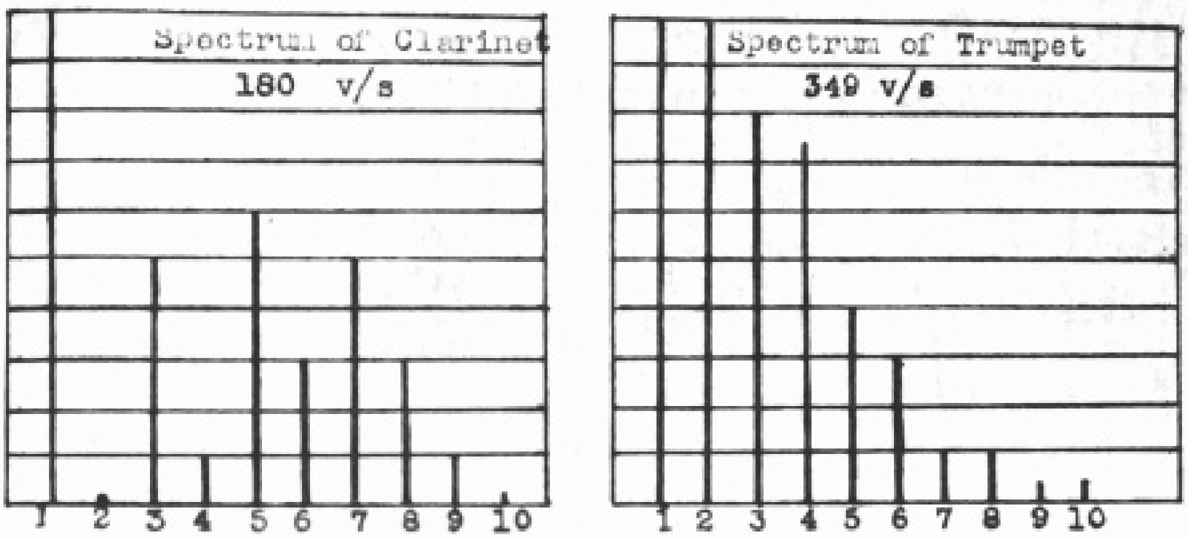

Figure 12. Sound spectra charts for two band instruments showing the relative harmonic content of a single note as played on each instrument. (From Culver, Musical Acoustics, 1956.)

are present.

Figure 13 indicates the frequencies in cycles per second of various instruments and sounds. The solid black line indicates the fundamental frequency range. The dotted line indicates the harmonics, or overtones. From the chart it can be seen that the fundamental and harmonic frequencies of these instruments range from approximately 27 to nearly 16,000 c/s. In The Practical Hi Fi Handbook, King declared that:

> Tests have revealed that distortion--free reproduction of music containing harmonic components up to come 18,000 c/s gives the sensation of considerable mutilation, when passed by way of a filter which chops off all frequencies above 7,000 c/s--not only to a person whose hearing is unimpared up to 18,000 c/s, but also to one who is essentially deaf at 7,000 c/s.[1]

This would indicate that if a faithful recording of the band is going to be achieved all frequencies, both fundamental and harmonic, must be recorded. LeBel reiterated this as follows:

> A sound will not be perfectly reproduced by electrical or mechanical means unless the harmonics involved are also reproduced. These harmonics, at various frequencies and different degrees of loudness, give the character of the tone to the sound of each instrument.[2]

Intensity and loudness. The ear is much less sensitive to changes in volume than it is to changes in pitch. Instead of following a linear

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[1] King, op. cit., p. 12.

[2] C. J. LeBel, How To Make Good Tape Recordings (New York: Audio Devices, Inc., 1956), p. 15.

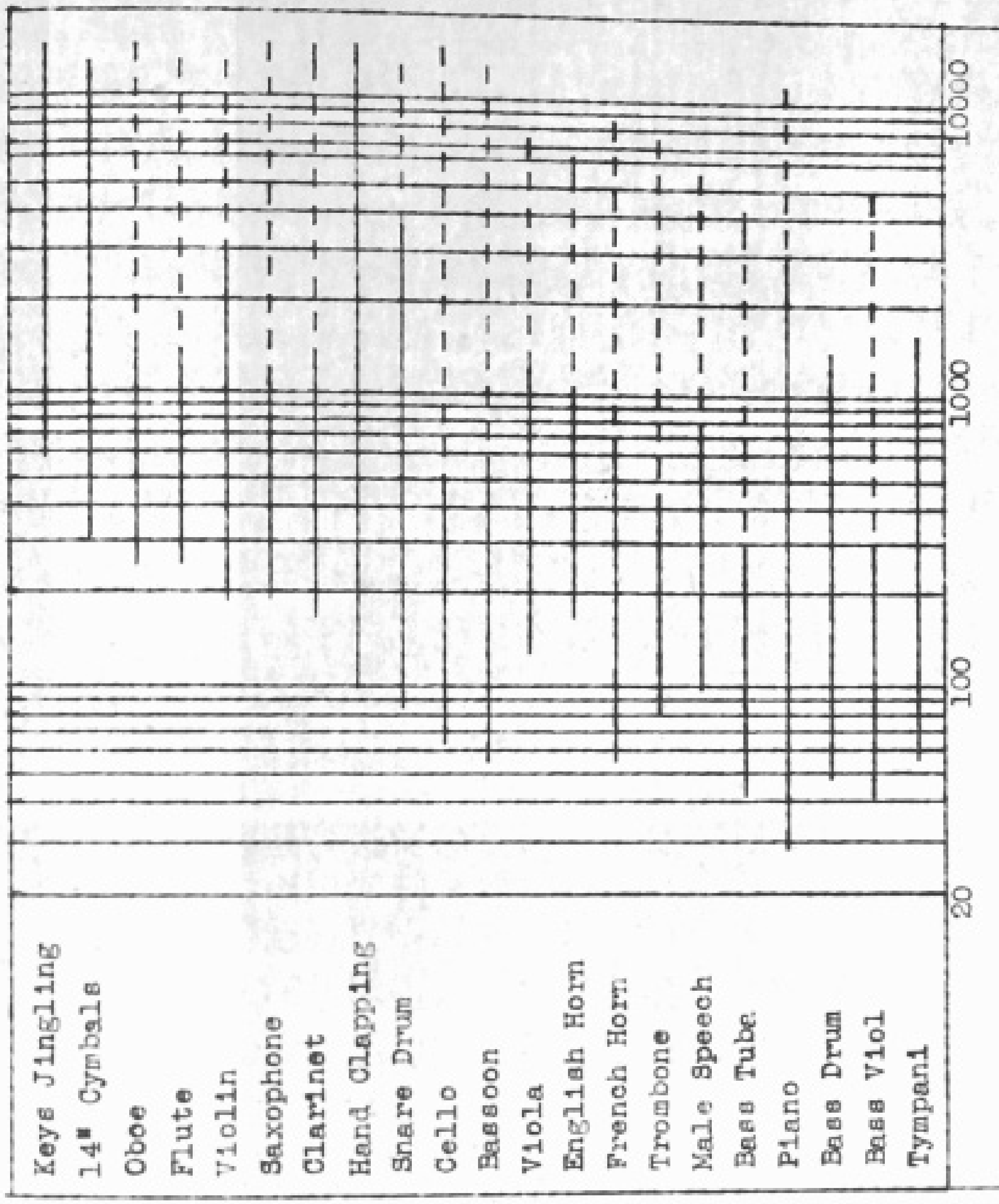

Figure 13. Frequency range of various instruments and sounds. Solid lines indicate fundamental frequency range. Dotted lines indica harmonics. (From Weiler, Tape Recorders and Tape Recording, 1956.)

law, the sensitivity of the ear to change in loudness or intensity is logarithmic.[1] This means that the impression a listener receives when a sound of a certain volume is increased in proportion to the two sound levels. This logarithmic ratio is expressed in decibels (usually abbreviated db).[2]

A sound twice as loud as a reference sound is 3 db higher in level. When a sound is four times louder than another, it is 6 db higher in level. When it is eight times as loud, the intensity level is 9 db higher. A sound that is ten times louder than another, is 10 db higher. When a sound is one hundred times louder than another it is said to be 20 db higher.[3]

It was stated above that the ear is not very sensitive to changes in intensity. This is substantiated when it is known that anything less than a doubling of the sound (a 3 db increase) receives scant notice. A change of 2 db is just about discernible by the average person, while a change of 1 db is hardly perceptible to the ear.[4] Then, if we are to record with accuracy all frequencies, both fundamental and harmonic, should be no more than 2 db from the point of reference.[5]

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[1]King, loc. cit.

[2]Harry F. Olson, Musical Engineering (New York: McGraw-Hill Book Company, Inc., 1956), p. 15.

[3]Weiler, op. cit., p. 24.

[4]Herman Bustein, "Understanding the Decibel," Hi Fi Stereo Review, VII (August, 1962), 48.

[5]Music Educators National Conference, op. cit., p. 230.

<u>Impedance</u>. The resistance of a device to the flow of electrical current is termed impedance, and is expressed in ohms.[1] There are three ranges of impedance inherent in microphones; high impedance (Hi-Z), medium impedance (Med-Z), and low impedance (Lo-Z). Twenty-five to fifty ohms is considered low impedance, 125 to 250 ohms is medium impedance, and anything over 1,000 ohms is high impedance. It is not necessary to match a microphone's impedance exactly to the input impedance of the recorder, but it is essential that a low impedance microphone be used with a low impedance input, a medium impedance with a medium impedance input, and a high impedance with a high impedance input.[2] Most semi-professional and non-professional tape recorders normally demand a high impedance microphone. If there is any doubt the recorder manual will indicate the type of input.

Impedance becomes an important consideration when the length of the connecting cable to the recorder is over fifteen feet. As the cable is lengthened over fifteen feet the high frequency response is cut down with a high impedance microphone. Also, the longer the cables are with a high impedance microphone the more it tends to pickup hum in its inter-connecting cables. The lower the impedance of the microphone the less it

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[1] Donald C. Hoefler, <u>All About Hi Fi Tape Recording</u> (Greenwich, Connecticut: Fawcett Publications, Inc., 1958), p. 84.

[2] Holt, <u>op. cit.</u>, p. 41.

tends to pick up hum. Since the placement of the microphone for the most desirable pickup often necessitates the use of a long connecting cable between the microphone and the recorder, it is advisable to use a low impedance microphone. This will allow for the use of a connecting cable as long as seventy-five feet.[1]

Low impedance microphones can be matched to a high impedance recorder input by the use of a special plug-in transformer that can be supplied by most recorder manufacturers. If this is not possible, an external cable type transformer such as the Shure A86A or Electro-Voice 502A may be connected in the cable at the tape recorder.

Acoustics. The acoustics of the room in which a recording is made affects the sound that is impressed on the tape. Sound waves may reach the microphone either directly from the source or as reflected sound waves. These reflected sound waves may be reflected once or many times. With each reflection the sound is momentarily later than the direct sound wave when it reaches the microphone. "This prolongation of the original sound, due to many reflections, is designated by the term "reverberation."[2] With each reflection some of the sound is absorbed by the reflecting surface until its energy is dissipated. This prolongation, if the reflected waves are still strong enough, will hang over until it

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[1]Music Educators National Conference, op. cit., p. 231.

[2]Culver, op. cit., p. 281.

may seriously interfer with the proper reception of music.[1]

Some musical frequencies are also absorbed to a greater extent than others. Reflections may also change and redistribute the relative intensities of the harmonics.[2] For this reason it is wise to have the direct waves as strong as possible as compared to the reflected waves if an accurate facsimile of the original sound is to be obtained.

It can be deducted from the foregoing that the stronger the direct waves the more accurate is the recorded sound.

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[1]Culver, loc. cit.

[2]Weiler, op. cit., p. 51.

CHAPTER III

TECHNIQUES OF THE MICROPHONE

Chapter III first discusses the factors to consider in obtaining a microphone that is capable of giving good results in tape recording the school band. However, a good microphone will obtain satisfactory results only if it is used properly. The use of the microphone is discussed in the concluding section of Chapter III.

I. SELECTION OF THE MICROPHONE

Each of the factors discussed in Chapter II that apply to the selection of the microphone has been considered. The cost of the microphones has been weighed in the selection of the microphone because it is impossible for many schools to obtain a professional quality microphone. The price ranges discussed will be as follows: low, less than forty dollars; medium, forty to eighty dollars; and high, above eighty dollars.

Frequency response. In Chapter II it has been pointed out that band instruments produce frequencies that range from 27 c/s to 16,000 c/s. If the sounds from these instruments are going to be recorded faithfully, the microphone ideally must respond to this range of frequencies with the same intensity with which they are present. Since the ideal has not been achieved even in the most expensive professional equipment, standards must be set which will give good quality results within a medium price range.

In Chapter II it was determined that a change of two db is just discernible to the ear. Any change of less than two db then will not be heard. The standard of a plus or minus two db from the reference line will be adopted in the further consideration of the microphone.

Through examining microphone specifications it became apparent that the response of a plus or minus two db down to twenty-seven c/s has been achieved only with professional microphones. A more realistic low frequency response of a microphone for school use would be a plus or minus two db down to forty c/s. This should not be interpreted to mean that the microphone does not respond at all to frequencies below forty c/s. It does say that the frequencies below this point are more than two db from the reference line. Only those frequencies corresponding to the lowest four notes on the piano would not be picked up with the same intensity as those above forty c/s. This would not limit the recording appreciably since band instruments seldom play in this very low range.[1]

A more practical upper limit would be 15,000 c/s, making it possible to procure a microphone in the medium price range. As is true at the low frequencies, this does not mean that those frequencies beyond 15,000 c/s are completely ignored, but that the microphone does not respond with the same intensity as those below 15,000 c/s. Only those harmonics falling within a range of slightly more than a semi-tone would be recorded at less than a plus or minus two db of the reference line.[2]

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[1]Holt, *op. cit.*, p. 42. [2]Weiler, *op. cit.*, pp. 25-27.

The frequency response of the microphone for school use in recording the band should be a plus or minus two db 40 to 15,000 c/s or better.

Impedance. Since it is often necessary to have a connecting cable of over fifteen feet in length to obtain the best placement for the microphone, a low impedance unit is desirable.[1] This is true even though the input of the tape recorder being used requires a high impedance input. A low to high impedance microphone transformer is required to connect a low impedance microphone to the high impedance input of a tape recorder. These should be connected in the microphone line cable as close to the tape recorder as is physically convenient (usually one to two feet).

Many tape recorder manufacturers can supply these transformers. Microphone manufacturers also can provide them. Two such transformers are the Electro-Voice 502A and the Shure A86A. These each list at $10.29 from Allied Radio, Chicago.

Many microphones are of multi-impedance. It is possible on some microphones to change impedance by a small switch so marked at the base of the microphone. In some cases a simple wiring change is necessary. This should be done by a competent radio repairman.

A microphone with low impedance is recommended for recording the school band.

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[1] Music Educators National Conference, op. cit., p. 231.

Polar pattern. Chapter II discussed the desirability of achieving as high a ratio of direct to reflected sound waves as is possible to obtain the most faithful recording of the band. Also, in recording a public performance it is important to reject as many extraneous noises as is possible.

The microphone with a cardiod or unidirectional pattern rejects the reflected waves from its back, thereby cutting down on the amount of reflected waves that it responds to. Compared to the omnidirectional or bidirectional microphone it is possible to maintain a higher ratio of direct to reflected sound waves with a cardiod or unidirectional unit.

The cardiod is recommended over the unidirectional microphone because it has a wider response field in the areas at right angles to the front axis. Examination of Figure 10 shows this to be true. This is advantageous because of the customary band seating arrangement. The cardiod can be placed closer to the band and still have all band members within the pickup pattern. By so placing the microphone closer to the band, the intensity of the direct sound waves are increased with little increase in the reflected waves.

A microphone with a cardiod pickup pattern is recommended.

Type of microphone. In Chapter II the frequency response of the carbon microphone was found to be insufficient to respond to all frequencies necessary to record the band. Neither was this response linear or flat. The internal noise level, which would introduce extraneous noises into the recording, is very high. Most carbon microphones have an omnidirectional pickup pattern. They were found to be inherently of high impedance. The carbon microphone could not be considered for good quality band recording applications.

Crystal and ceramic microphones have a frequency response of approximately 100 to 9,000 c/s. This was found by examination of the specifications of twelve available microphones from three major American manufacturers. This response was not very flat or linear; and individually they varied a great deal. All had an omnidirectional pickup pattern. They were limited to a cable of fifteen feet or less because they were of high impedance. They were reported to be rugged and to stand up under normal operating conditions. However, the crystal microphone is affected by high temperatures and humidities. Their price range was in the low to low medium price range.

It was determined from microphone specifications that a good quality dynamic microphone with a frequency response of a plus or minus two db 40 to 15,000 c/s could be obtained.[1] Dynamic microphones were found to be constructed with various polar patterns, including the recommended cardiod pattern. They are available with low, medium, or high impedance. Some were of a multi-impedance. They are extremely rugged, an important consideration for school use. Manufacturers have demonstrated their ruggedness on some models by driving nails with no

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[1]By examination of microphone specifications from companies listed in Bibliography under Other Sources.

apparent damage other than to the finish. They are available in the medium to high price categories.

A good quality dynamic microphone is recommended for band recording applications.

A very linear frequency response of a plus or minus two db 40 to 15,000 c/s or better has been achieved in good quality ribbon or velocity microphones. They are available with any of the pickup patterns. The ribbon microphone is constructed with any impedance range or with a multi-impedance arrangement. It is quite fragile and easily damaged because of the high compliance of the ribbon. It is not satisfactory for outdoor use as even a light breeze will activate the ribbon, creating a rushing sound on the recording. A wind shield will cut down on this effect but will not completely eliminate it. The price of the ribbon unit is in the medium to high price range.

Percussion instruments and the piano are recorded especially well by a ribbon microphone. This type of unit is the one that is preferred in most professional recording applications.[1] It is very satisfactory in every respect except for the necessity of care in handling. For this reason it cannot be recommended for school use.

The condenser or capacitor microphone falls into the very high price range. Its frequency response is very linear, exceeding our

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[1] George Riley, "How to Choose the Proper Microphone," Electronics World, LXIV (September, 1960), 37.

minimum of a plus or minus two db 40 to 15,000 c/s. It compares in ruggedness to the dynamics. A step down preamplifier is necessary because of its inherent high impedance. It requires its own external power supply. The capacitor microphone is available with any desired polar pattern.

The condenser or capacitor microphone was not considered because of its high cost.

Summary of microphone specifications. The dynamic microphone is recommended for school use. It should have a frequency response of a plus or minus two db 40 to 15,000 c/s or better. The polar pattern should be cardiod.

The prices of microphones having these recommendations varies from forty-five dollars and up. The suggested manufacturers list price is a good indication of the over all quality of a microphone. After consideration of the above recommendations the list price should be weighed.

II. PLACEMENT OF THE MICROPHONE

Placement of the microphone was discovered in Chapter II to be a very critical part of the job of securing a recording that is an accurate likeness of the original sound. The writer has not found a complete set of "rules" that will apply to every situation. However, through his experience and the knowledge of recording engineers, the writer has found a number of procedures and guides that can be applied to secure a more authentic sound.

Acoustics

Chapter II disclosed the ratio of direct to reflected sound waves should be as high as possible. Band one of the accompaning tape illustrates the effect of reflected waves upon the sound. A paragraph four sentences in length was read three different times under three different circumstances. This test could have been done with an instrument, but the voice gave a more graphic illustration of the effects of the acoustics upon a recording.

Test one showing the effect of acoustics upon recording. The first test was done in the instrumental music room of the Fort Dodge Senior High School. The first sentence was read at a distance of one foot from the microphone, the second at four feet, the third at eight feet, and the last at twelve feet. In each case the volume was adjusted so that each sentence would be recorded at the same intensity.

A second reading of the paragraph was made in a typical classroom at the Fort Dodge Senior High School to illustrate the effect of a very reverberant or live room upon a recording. Exactly the same procedure was followed as in the first reading.

A third test was also made in the same classroom at the same distance as the two previous readings. However, this time the recorder volume level was held constant.

The first sentence of test two was spliced on after the first sentence of test one. The first sentence of test three was spliced on following test two. The second set of sentences was arranged in the same manner and spliced on immediately following the first set of sentences. This procedure was continued until the three sets of recordings were combined into a master tape that contained each sentence three times in succession, recorded at the same distances but under different conditions.

Test one of the tape graphically represents the effect of reverberation upon a recording. Subtle differences in the tone color became apparent on listening to the tape. Also, it sounded as though each sentence within each group was recorded at different distances. The test illustrated the effect of reflected sounds upon the recorded sound and demonstrated the importance of the proper microphone placement.

Number of Microphones

The engineering department of the National Broadcasting Company is categorically committed to the principle that the best musical pickup can be made on one microphone only.[1] The chief objection to a multiple microphone pickup by all engineering sources that the writer conferred with was that one instrument or group of instruments have a tendency to stand out too prominently and thus upset the balance. A further objection was that more than one microphone has the tendency to muddy up the sound. Harold Ennis further verified this by stating, "Multi-microphone setup is

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[1] Albert Crews, Radio Production Directing (Cambridge, Massachusetts: The Riverside Press, 1944), p. 287.

never quite as clean, probably because of the several paths each sound can take."[1]

Test two illustrating use of two microphones. The second test on the demonstration tape illustrates the use of two microphones. This recording was made with one microphone centered from left to right and three feet back of a line drawn across the front of the band. It was raised to a height of nine feet. The second microphone was placed fifteen feet to the front of the first row, also nine feet high. They were connected to the recorder by means of a dual connector. It is apparent on the recording that the brasses, in particular the trumpets, and the percussion over-balance the woodwinds. Neither is the recording as clear and clean cut as is possible with only one microphone. This would seem to be due to the different paths that the sound can take.

The conclusion from this data was that one microphone will give the best results in recording the band. All further conditions were considered with the use of one microphone.

Experiments on Distance of Microphone from the Band

The following groups of recordings were made with a sixty-five piece band. This size was decided upon because it can be considered as a medium sized organization. This was dictated by the impracticability

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[1]Harold Ennes, Broadcast Operators Manual (New York: John F. Rider, Inc., 1947), p. 70.

of attempting to make tape recordings of all the various sizes of bands with all the variations in heights and distances in placement of the microphone. These findings can be adapted to larger or smaller bands with only slight adjustments. These variations will be pointed out whenever the writers experiences has shown them to be true.

All microphone distances referred to in this section of the report were measured from the intersecting point of a line drawn from front to back through the middle of the band and a line drawn immediately across the front row of the band. This point is referred to as zero feet. The experiments were done with the microphone on a floor stand at a height of six feet. Four distances were chosen that are representative of those that might be used in recording applications. Specific situations might limit those distances that can be considered because of the size of the room.

Test three with microphone placed at zero feet. Test three of the tape is a recording of a band with the microphone place at zero feet from the band. By listening to the tape it became apparent that the brasses and percussion completely overbalanced the woodwinds. The low frequencies of the woodwinds were almost completely lost. This gave the woodwinds an unrealistic sound composed primarily of the upper frequencies. The upper harmonics predominated the woodwind sound. Those instruments at the front on the outsides were somewhat lower in intensity in comparison to the live sound.

<u>Test four with microphone placed at five feet</u>. The microphone was placed five feet in front of the band for test four. On this test the woodwind sound was more authentic than that of test three. Their low frequencies are nearly equal to the high frequencies in intensity. The balance between the instrument families was much nearer the real sound, although the brasses were still somewhat heavy in comparison to the live sound. The percussion were still overbalancing the other sections although not as much so as on test three.

<u>Test five with microphone placed at ten feet</u>. The microphone was placed ten feet in front of the band for test five. The balance between the brass, woodwind, and percussion was better than that at zero and five feet. The presence of the woodwinds was excellent. There did seem to be a slight coloration of the upper harmonics of the woodwinds. This would be due to the presence on the tape of more reflected sound waves than on the previous tests.

<u>Test six with microphone placed at twenty feet</u>. Test six of the tape was made with the microphone twenty feet in front of the band. This requires a larger room than was necessary for the previous test, which introduces the possibility of reverberation exerting a greater effect upon the recording. The room in which test six was made was a typical small gymnasium, forty-five feet by eighty-five feet with the ceiling twenty-two feet high. The band was seated at one end facing the long way.

The balance on this test was excellent in comparison to the live sound. All sections were in their proper perspective. There is an excessive coloration of the sound due to reverberation. The upper harmonics are more intense than in the veritable sound. There is a ringing in the percussion that was not present on the previous test.

Test seven in Fort Dodge Senior High School band room with microphone at eight feet. The previous test tapes made it apparent that the best distance to place the microphone to achieve the most accurate sound in comparison to the live sound was somewhere in between five and ten feet in front of the band. The maximum distance possible in the Fort Dodge Senior High School band room is eight feet six inches. Test seven was made at eight feet, just six inches from the wall. The balance on this test was satisfactory although the percussion was somewhat heavy and muddy. There seemed to be an undue amount of coloration that could have been due to the close proximity of the microphone to the wall.

Test eight in Fort Dodge Senior High School band room with microphone at seven feet. Test eight on the tape was made with the microphone placed seven feet from the band. It compared very closely with test seven in balance. The sound was excellent in comparison to the true sound. The coloration and muddiness that was characteristic of test seven was improved. The brasses were slightly heavy in comparison to the authentic sound. This test recording was most nearly true to the live sound of any of the previous tapes.

Summary of experimentations on distance of the microphone from the band. The experimentations of the tape indicate that the most satisfactory recording can be achieved with the microphone placed at a distance of five to ten feet from the band. The test recordings indicated that in a small room the distance should be nearer five feet, and as the room becomes larger the microphone should be move farther from the band. The experiments denoted that, if the sound is going to be an authentic reproduction of the live sound without excessive coloration by the reflected sound waves, the maximum distance that the microphone can be from the band is ten feet.

Experiments on Height of the Microphone

The test recordings made on the accompaning tape concerning the most satisfactory height to place the microphone were first conducted with the microphone at a distance of seven feet, indicated in the summary of the experiments on distance. All heights were measured from the floor level of the lowest row of players.

Test nine with microphone at height of eleven feet. Test nine was conducted with the microphone at nearly the maximum height possible in the Fort Dodge Senior High School band room. The height of eleven feet places the microphone six inches from the ceiling. Two major characteristics were apparent when listening to this test. The first was that there was excessive coloration of the sound, particularly of the higher harmonics. The tone was not realistic with the veritable sound.

Secondly, the percussion were heavy as compared to the true balance of sound. There also was unusual reverberations, almost echo, in the percussion sound. The balance between brasses and woodwinds was authentic. Some of the presence of the woodwind sound is lacking.

Test ten with microphone at height of nine feet. The next test on the tape was done with the microphone at a height of nine feet. The balance between the woodwinds, brasses and percussion was satisfactory. The coloration of the higher frequencies that was apparent on test eleven, was improved. The woodwind presence was good.

Test eleven with microphone at height of six feet. The final test in the Fort Dodge Senior High School band room was performed with the height of the microphone at six feet. Compared with test ten the brasses were somewhat heavy. Some of the woodwind presence was absent in comparison to the previous test. This sound was not as authentic as that of test eleven.

Summary of experimentations with height of microphone. The experimentation with the tape indicate that the most satisfactory recording can be achieved with the microphone adjusted to a height of nine feet. A contributing factor here is the height of the ceiling. The tests showed that unreal coloration of the sound resulted if the microphone was placed too close to the ceiling. The tests indicate that the microphone should be placed as high as possible, or until reverberation from the ceiling becomes excessive. If the brasses overbalance the woodwind and percussion it indicates that the microphone is too low. If the percussion sound is too heavy and their sound is unrealistic the indications are that the microphone is too high. In either case the presence of the woodwinds is lacking.

CHAPTER IV

SUMMARY AND CONCLUSIONS

I. SUMMARY

The purpose of this study was to prepare a manual of microphone techniques for achieving the best possible rehearsal recordings by the school band director for his study to determine those areas where improvement is possible. The writer surveyed books on acoustics, acoustical and radio engineering; periodicals in the high fidelity field; and materials from microphone manufacturing companies. Chapter II explained the terms and processes related to tape recording that are necessary to comprehend all factors involved in the selection and use of the microphone. Chapter III discussed the selection and placement of the microphone.

II. CONCLUSIONS

The study found that the dynamic microphone of low impedance with a cardiod pickup pattern was the best for school use in recording the band. It should have a frequency response of a plus or minus two decibels from 40 to 15,000 cycles per second. The experiments conducted on the tape indicate that the microphone should be placed from five to ten feet in front of the band at a height of nine feet. The exact placement depends on the size and acoustics of the room and the size of the band. If the room is large and space allows, the microphone should be moved farther away from the band. It may also be necessary to move the microphone out with a large band to place all of the bandsmen within the pickup pattern. The study shows that the microphone should be a minimum of two feet six inches from the ceiling. The study indicates that if the microphone is any closer than this undue coloration of the percussion results. The studies indicate that if the percussion is too heavy the microphone is too high. If the microphone is too low the brasses overbalance the other sections. In either case the woodwind presence is lost.

The experiments conducted on the tape cannot be interpreted to mean exact distances that will be the most satisfactory in every situation. There are an infinite number of variations in room sizes, shapes, and acoustics. The size of the band may possibly dictate minor variations. The conductor's ear is another factor that, through personal preference, may dictate some changes. These variables may result in some adjustments of distances, but the study and the experiments indicate that these distances will give the most satisfactory results.

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APPENDIX

Tape Recording Experiments.

All experiments conducted on the accompaning tape were done with a Roberts 990 tape recorder. The microphone used was a Shure 330S ribbon microphone of low impedance with a cardiod pattern.

Test one. A paragraph four sentences long was read under three different situations. First, it was read in the Fort Dodge Senior High School band room. The first sentence was read with the microphone placed one foot from the speaker. The second sentence was read with the speaker four feet from the microphone. The speaker was eight feet from the microphone for the third sentence, and twelve feet for the fourth sentence. The recording level was adjusted on the tape recorder so that each sentence was recorded at the same level. The same procedure as the first was conducted in an ordinary classroom of the Fort Dodge Senior High. The paragraph was read again in the same classroom under the same circumstances as the previous times except that the recording level was held constant for all sentences.

Test two. Experiment using two microphones. Microphone A was placed at zero feet nine feet high. Microphone B was placed at fifteen feet, also nine feet high.

Test three. The microphone was placed zero feet in front of the band at a height of six feet.

Test four. The microphone was placed five feet in front of the band at a height of six feet.

Test five. The microphone was placed ten feet in front of the band at a height of six feet.

Test six. The microphone was placed twenty feet in front of the band at a height of six feet.

Test seven. The microphone was placed eight feet in front of the band at a height of six feet.

Test eight. The microphone was placed seven feet in front of the band at a height of six feet.

Test nine. The microphone was placed at a height of eleven feet at a distance of seven feet from the band.

Test ten. The microphone was placed at a height of nine feet at a distance of seven feet from the band.

Test eleven. The microphone was placed at a height of six feet at a distance of seven feet from the band.